Geology 12 Summaries

Name:___________________

Brief Minerals Summary

- Silicates (Oxygen 46.6% and Silicon 27.7% of crust) make up most of the crust (inculdes many minerals, all those on Bowens and more)

- be able to use the mineral data sheet in the data booklet

Definitions

cleavage - break along a flat plane
fracture - doesnt break along a flat plane (ie quartz)
hardness - resistance to being scratched (but may be brittle)
specific gravity - density - how heavy for its size
colour - may vary for the same mineral
streak - consistant for the same mineral, colour of minerals powder
lustre - shine or lack of - vitreous (glassy), earthy, metallic (metallic minerals have dark streaks, non-metallic have light streaks)
special properties

- magnetite - *magnetic*
- calcite - *double refraction, fizzes with acid, flouresces*
- K feldspar - *radioactive*
- halite - *salty taste*

Commonly Tested Minerals

quartz - hexagonal prismatic crystals, conchoidal fracture, hardest common mineral (7), many colours, framework silicate, vitreous
mica - muscovite (light) and biotite (dark) - common in metamorphic rocks (mica lines up under pressure creating foliation), sheet silicates, vitreous
garnet - metamorphic formation from some shales, hard (7), red, gem stone, vitreous
asbestos - carcenogenic, good insulator, metamorphic formation
hematite - several colours but always a redish brown streak
galena - dense, metallic, cubic crystal structure
pyrite - fools gold, causes acid rock drainage, often found near gold, metallic
chalcopyrite - fools gold, mined for Cu, gold much denser, metallic
boronite - peacock ore, mined for Cu, metallic
graphite - metamorphic, lubricant, pencil lead
gold - native element - unattached chemically, extremely dense
flourite - cubic crystals but cleaves octahedrally, purple, green, vitreous

Find old exams on the ministry website <u>and</u> the Geology section of my sharepoint site.

Name:__________________

Brief Rocks Summary

<u>Rock Cycle</u> - any type of rock can become any type of rock depending on the processes it undergoes. Igneous form from melting and solidifying, sedimentary form from erosion and lithification, and metamorphic form from heat, pressure and/or chemical action.

<u>Igneous</u>

- if magma cools slowly (intrusively, plutonically) there is more time for large crystals to form
- if magma is thin it is easier for large crystals to form
- if magma cools quickly (extrusively, volcanically) a glassy and/or frothy (vesicular) texture may result
- magma near the surface is under less pressure so gas dissolved in it can undissolve and bubble out
- pyroclastic textures occur in an explosive volcanic setting
-porphyry has two stages of cooling and thus two crystal sizes
- felsic - viscous (thick), light coloured, less dense, explosive volcano from trapped gasses, rhyolitic, composite volcano
- intermediate - similar properties to felsic (explosive, etc.), andesitic
- mafic - thin, dark, denser, usually hotter, smooth flowing, basaltic, sheild volcano
- be able to use the Minerals in Igneous rocks chart (to identify what rock you are looking at and how much of each mineral is in it, also shows compositionally equivalent rocks) and Bowens reaction series (to determine which crystalizes first)
- Bowens says olivine crystalizes first, quartz last, as magma cools
- intrusive features: sill (parallel), dike (cuts across), xenolith (unmelted fragment), etc
- obsidian - glassy, can be vesicular, cools quickly, conchoidal fracture, generally felsic
- pumice - vesicular, cools quickly, traps gas trying to escape, floats on water
- pegmatite - very large crystals (can be meters long!), from thin magma, slow cooling
- tuff - volcanic ash glued together

<u>Sedimentary</u>

- clastic - sediments glued together (lithified), conglomerate (largest), sandstone, shale (smallest), breccia (angular)
- chemical - precipitate from solution, see crystals, limestone ($CaCO_3$) - fizz, chert (silica)
  - evapourite - gypsum, halite (rock salt)
- stratification - layers in sediment, bedding planes
- crossbedding - formed as currents flow and change direction over the years
- ripple marks - asymmetrical: streams, symmetrical: beach, lake bottom
- mud cracks - in fine grained mud that has dried, widest at top
- graded bedding - when water flows suddenly stopped largest sediment settles first on bottom (turbidite)
- varves - annual layers on a glacial lake bottom
- the further a sediment has been transported the more physically mature it will be
- the longer in contact with water, the more chemically mature

Metamorphic

- original rock changed form due to heat and/or pressure and/or chemical action

- shale (sed.) --> slate (mica flakes line up under pressure causing some foliation) --> phyllite (more foliation) --> schist (more foliation, mica more visible) --> can become gneiss under even more pressure sometimes
- granite (ig.) --> gneiss (compositional banding)
- conglomerate (sed.) - metaconglomerate (stretched pebble)
- limestone (sed.) - marble (bigger crystals from recrystallization)
- sandstone (sed.) - quartzite (recrystallized quartz grains)

- foliation - parallel alignment of linear or planar minerals (slate, schist, etc)
- non-foliated - rocks that consist predominately of equidimensional grains (quartzite, marble)
- compositional banding - recrystallizing minerals in the rock segregate into bands of differing composition or texture.

- contact metamorphism - mostly heat from contacting pluton changes surrounding country rock (ie marble, quartzite) --> contact meta.
- regional metamorphism - mostly pressure from tectonic forces changes rock (ie slate)
- chilled margin - edges of pluton cool more quickly therefore has smaller crystals

Astronomy

① Nebular Model - nebula (cloud of dust and gas) rotating counter-clockwise pulled together. Most material formed the sun at the centre, remainder formed planets - denser ones closer to sun (inner planets), less dense further out (gas giants)

②

Inner / Terrestrial	Outer / Jovian (not Pluto)
small, rocky	large, gas giants
dense	less dense
few moons	many moons
warmer	colder
no rings	rings

③ Craters - thick atmosphere stops meteors from hitting, plate tect + erosion erases (ie Venus + Earth)

④ Magnetic field - need liquid core and fast rotation on axis

Resources - Quick Summary

- Economic minerals are profitable to mine, it has a high enough concentration factor, depends on demand and price the metal can be sold for, easy & safe to mine (environmentally), easy to access, large enough amount present in location.

- Magmatic deposits include
  - kimberlites - magma brings up from depth - diamonds
  - fractional crystallization -settles to bottom of magma chamber-chromite, magnetite
  - pegmatites - large crystals commonly from residual magma-lithium, boron,uranium
  - hydrothermal - hot fluids escape from cooling magma or heated subsurface water, carry dissolved metals, deposit ores (as sulfides or native elements) as cool
    - copper, lead, zinc, gold, silver, platinum, uranium

- Magmatic activity is commonly located at plate boundaries (so it is a good place to mine)

- Minerals and substances of value - see tables you copied out in class

- How oil and natural gas form - lots of marine organisms (rich in carbon and hydrogen) die, settle to sea floor, buried rapidly so doesn't decay, increase in P and T, slowly over time, chemical reactions occur that break down the large complex organic molecules into simpler hydrocarbon molecules, as breakdown continues large thick hydrocarbons become progressively smaller and thinner, finally very simple, light, gaseous molecules (natural gas) is formed. Mostly occurs between 50 and 100 degrees C, above that methane forms. Timewise no petroleum is found in rocks younger than 1 to 2 million years old.

- Porosity - the number of holes (pores) in a rock
  Permeability - the connectedness of the holes (pores)
  a good oil well will have <u>high porosity and high permeability</u>

- Oil traps - impermeable cap rock to hold oil down, porous and permeable reservoir rock, oil and gas float on water. See examples pg 446 in text.

- Stages of coal formation - see Figure 21.8 pg 451, study it!
  - peat, lignite, subbituminous, bituminous, anthracite

low heat, low carbon	high heat, high carbon
softer	harder

  - in formation the higher the T and P and longer the time, the harder and higher heat coal is produced
  - if T too high, metamorphosis and graphite is formed (can't burn)
  - coal is the remains of land plants falling in swamp in tropical climate usually

Ways to locate mineral, rock, or petroleum deposits:
  - look for gravity highs
  - consider what happened in the area in the ancient past (see Geology of BC)

The Geological Formation of BC

In the distant past the west coast of Canada was near Salmon Arm. The continent was made of a granite batholith, that formed as the Earth cooled 4.5 billion years ago, and sedimentary rocks from erosion. Sediments were also building up into layers on the west coast as erosion washed them toward the Pacific Ocean. In the tropical climate that existed here, due to our more southern location on the globe (as a part of Pangea), there were many swamps where vegetation lived, died and fell into. There was an inland sea covering Alberta and Northeastern BC where marine organisms lived, died and were buried. (Dinosaurs also lived in this area.)

About 200 million years ago Pangea broke up.

About 170 million years ago several strings of volcanic islands (a terrane) collided with the coast (the collision took many, many years at the rate of a few centimeters a year). The sedimentary layers that had been piling up were folded and faulted (thrust faults) by the compressional forces and became the Rocky Mountains. BC would have been 300 km wider if the crumpling had not occurred. Erosion wore the Rockies down at the same time (and ever since) or they would be 10 km higher than they are now.

These volcanic islands (that collided) had their tops eroded off over time and isostacy caused their roots (batholiths, magma cooled underground) to be raised up. These are the current Coast Mountains that we see north of Vancouver.

More "recently" lava has extruded through the Coast Mountains forming Mt Garibaldi (near Squamish) and Mt Edziza (recent, north of Terrace).

A hot spot has formed the Anahim chain of volcanoes Southeast of the Queen Charlotte Islands. The North American plate moved northwest over the stationary hot spot forming the chain with the youngest (most recently formed) furthest east.

Also, the Juan de Fuca plate is subducting under the North American plate. This causes the composite volcanoes in the Cascade Mountains (i.e. Mount St Helen's, Mount Baker, etc.). It also causes the threat of the "BIG" 9.5 earthquake we are expecting here.

The Rock Types

BC has all three rock types:

Igneous - wherever there are volcanoes, roots of volcanoes, or dikes slicing through

Sedimentary - in the Rockies and all over BC from the erosion that has occurred (3/4 of the continent's exposed rock is sedimentary)

Metamorphic - in collision zones (from 170 million years ago or the subduction right now), involved significant T, P and water content changes yielding altered rocks

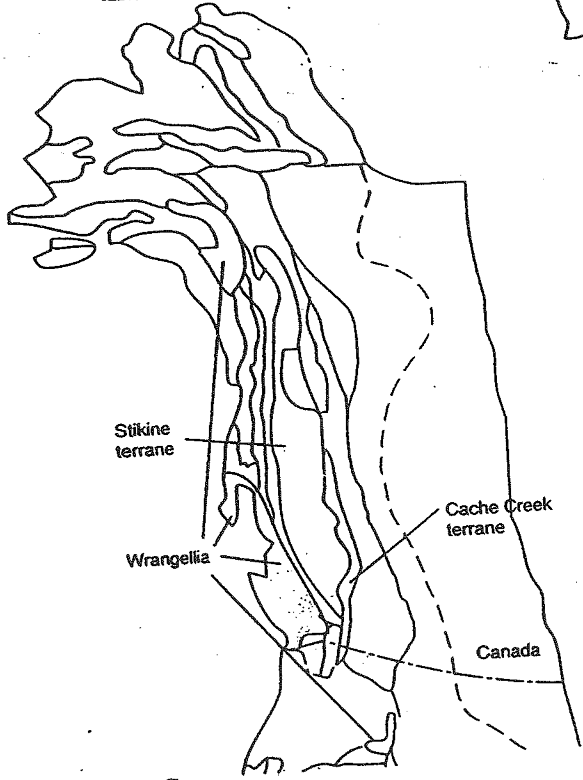
The Resources

The sedimentary layers in the Rockies contain coal that formed from vegetation falling into the swamps prior to the collision.

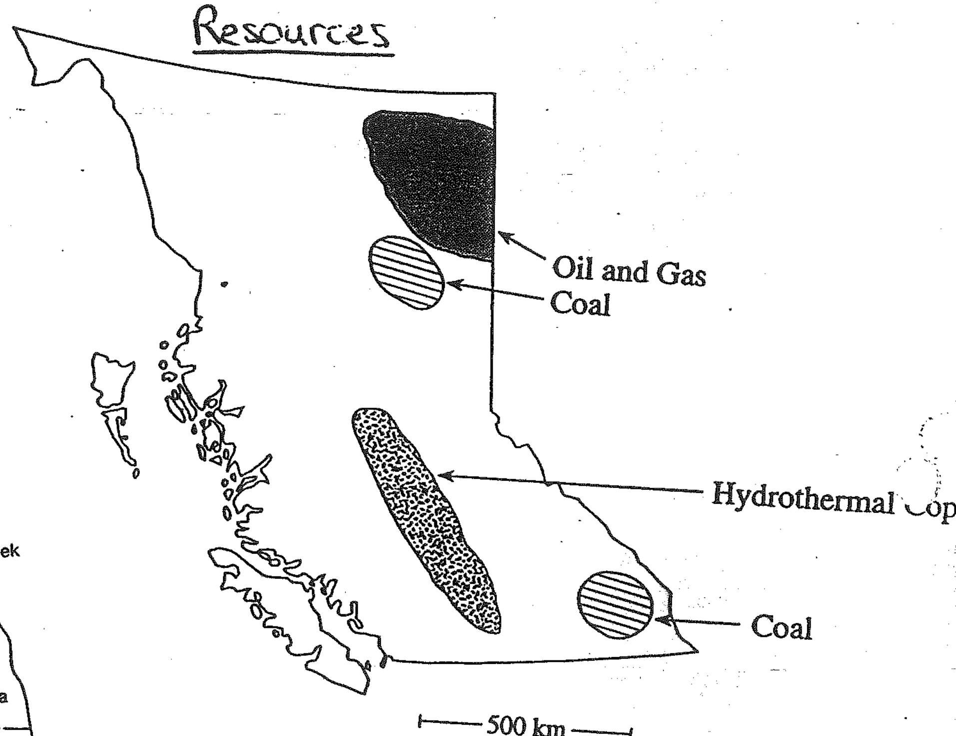
Northeastern BC and AB have oil and gas from the marine organisms that lived and died in the inland sea.

Metallic minerals (such as copper) are formed by magmatic processes and consequently are found near the Coast Mountains (roots of ancient volcanoes), Anahim chain (hot spot volcanoes), and Cascade Mountains (subduction volcanoes).

Terranes



Resources



Summary

BC formed by elongated segments of mini-continents (terranes) that drifted across the Pacific and docked onto the older part of North America. This pushed up the Rockies. Erosion (glaciers, streams, mass wasting, wind) has formed/is forming what we see today.

Name:___________________

Brief Geologic Time Summary

Relative age – put events in order by comparison to each other

- Faunal succession – no life from exactly duplicates
- Uniformitarianism – the present is the key to the past
- Original horizontality – sediments are deposited in flat-laying layers
- Cross-cutting relations – a fault or dike that cuts across layers is younger than the layers
- Correlation – two rocks containing the same fossil must be the same age
- Superposition – if undisturbed, the oldest layer is on the bottom
- Included fragments – pieces in the rock are older than the rock they are in (be they sediments or xenoliths)
- Unconformity – a break in the time record; between sedimentary layers where there has been erosion or a lack of deposition so it looks like time is missing; angular unconformity (layers above and below are not parallel) or disconformity (layers above and below are parallel)

Absolute age – finding a numerical age (i.e. radiometric dating, counting tree rings or varves, using index fossils)

Radiometric dating

Half-life – the length of time for half a radioactive parent sample to decay and become stable daughter; is unique for each radioactive element; never changes

To find the age using radiometric data: when a rock first forms (from magma especially) it only has parent in it which immediately starts to decay to become daughter. Scientists can look at the amount of parent compared to daughter to tell how many half-lives have passed. Then

$$\text{Age} = (\text{\# of half-lives}) \times (\text{length of half-life})$$

Sources of error in radiometric dating:

- Maybe there was some daughter present to begin with (sample appears older)
- Maybe some daughter escaped (sample looks younger) i.e. Argon is a gas
- Maybe some parent/daughter was added to the sample (looks younger/older)

Scientists can correct for possible errors by using more than one radiometric isotope and compare ages obtained for consistency.

Can get numerical age ranges for sedimentary rocks by radiometrically dating sills, dikes, lava flows, etc. which surround/cut across the sedimentary layers.

Note: Carbon 14 can be used for organic material only and its half-life is short (5730 years).

Geologic Timescale
Review the events that you wrote on the geologic timescale.

Fossils
Hard parts preserve most easily.
Usually fossilized in water since this is where sediments accumulate mostly.
Rapid burial (to avoid scavengers and decay). Effectively seal from bacteria.

To fossilize soft parts (a replica, not the soft parts themselves) – organism must be buried alive in deep, low oxygen water.

A fossil is a replica of the animal itself. A trace fossil is a replica of something left behind by the animal (footprint, burrow, feces).

Methods of fossilization
Original preservation – the original part remains
Carbonization – a "picture" in carbon; usually plants fossilize this way.
Replacement – a mineral (i.e. quartz) takes the place of the original structure
Permineralization – a mineral fills in the pore spaces of the original structure
Mold – sediments solidify around the shell, water flowing through dissolves the shell, and the hollow remaining shows the external features of the shell
Cast – sediments fill in the mold and show only the external features of the shell, no internal structure is present

An index fossil is a fossil of a plant or animal that lived for a relatively short time, was widespread geographically, is unique looking (easily identified), and was abundant.

Review the 4 pages of fossil phyla. Be able to recognize the phyla, know where and how they lived, approximately when and what are the living relatives (if any).

Punctuated equilibrium – life forms remained stable (didn't change) for long periods of time and then, all of a sudden, a major change occurred to be followed by long periods of stability.

Adaptive radiation – animals adapt to the environment they are in and consequently change from what their parents were.

Natural selection – survival of the fittest

Name:____________________

Brief Surficial Processes Summary

Weathering and Erosion

- Weathering - the breakup of rock in place
- Erosion - the breakup and transport of rock
- Physical (mechanical) weathering - physical breakup of rock without chemical change, i.e. ice wedging, exfoliation
- Chemical weathering - breakup of rock that is a result of chemical change, i.e. acid rain, water contact
- Biological wathering - breakup of rock that has to do with plants or animals (can be physical or chemical) i.e. acids of decay, roots wedging
- Bowens reaction series gives the order of susceptibility of chemical weathering (olivine most easily, quartz least readily)
- Mass wasting - downslope movement, triggered by earthquake or heavy rainfall, variety of speeds and types (see chart handed out in class)
- Mass wasting can be controled by planting on slopes, dewatering, barrier walls, etc

Running Water

- load - the material a stream carries; bed load - rolled along the bottom; suspended load - carried in suspension, never touches the bottom; solution - carried by being dissolved in the water
- sorting occurs as a stream slows down and selectively drops the heaviest material first
- more erosion and deposition results when the stream carries a greater load, moves faster (steeper gradient if all else is equal), greater discharge (more water), more erodable sediments in the stream channel. Meanders have erosion on the outside of the curve and deposition on the inside.
- Water transported particles are rounded, smooth (physically mature), chemically mature, small to medium sized, well sorted. Wind transported particles are well rounded, pitt-marked, chemically immature, small sized, very well sorted. Glacial transported particles are generally angular, chemically immature, all sizes, unsorted.

Glacier

Erosional features

- U-shaped valley,
- hanging valley (tributary glacier valley feeding into large valley),
- cirque (bowl-shaped at head of valley),
- horn (formed by three or more glaciers),
- arete (formed by two glaciers flowing parallel or two cirques back to back),
- striations (scratch marks from rocks embedded in ice).

Deposional features

- erratic (a large rock brought by a glacier),
- moraines (ground - till, recessional - as glacier retreats it may leave a pile along the way if it remains stationary, terminal - shows the point of furthest advance, lateral - along the side, medial - two laterals joined when glaciers merge),
- drumlin (if a glacier runs over an old moraine it becomes shaped like an upside down canoe),
- kame terrace (lakes at the sides of glacier, build up of sediments in the bottom),
- esker (stream in or on a glacier, stream bed deposited when glacier melts)

Ground Water

- Water table is the top of the zone of saturation (pores filled with water), zone of aeration (partly filled with water, partly with air) is above.
- Perched water tables are well above the regional where an impermeable rock (i.e. shale) provides a place for water to settle on.
- Confined water table has impermeable rocks above and below - artesian well.
- Aquifers are rocks capable of holding water - sandstone is good.
- Porosity - the number of holes, the more the better (can hold more water).
- Permeability - how connected the holes are, the more connected the better.

Name:________________

Brief Internal Processes and Structures Summary

Evidence for plate motion:

- earthquakes, volcanoes
- jigsaw fit
- tropical fossils in northern climates, glacial feature at the equator, sea shell fossils on mountain tops
- polar wonder curve
- magnetic stripes on the seafloor

Seafloor spreading - plates are separating and magma rises up to solidify along the ridge
Evidence - youngest rock along ridge, oldest furthest away
- magnetic stripes

Plate boundaries and associated volcanics, etc:

- converging - two plates colliding; subduction between ocean plate and ocean or continental plates; mountain uprising from continental-continental collisions; compressional forces, folds, reverse and thrust faulting; subduction zones form composite volcanoes (explosive, andesitic, layers)
- diverging - two plates separating (i.e. Mid Atlantic and Juan de Fuca ridges); tensional forces, normal faulting, new crust created; flood basalts (smooth flowing, basaltic)
- transform - two plates move horizontally relative to each other (i.e. San Andreas fault); shearing force, strike-slip faults

Around the world:

- Rockies (Canada) & Himalayans (N. India) & Alps (N. Italy) - collision between two continents
- Andies (S. America) & Cascades (US) - volcanic chains from subduction of ocean plate under continent
- Aleutians (Alaska) & Japan - subduction of ocean plate under ocean plate
- Appalachians (US) - folding from collision of plates

Plates move possibly because:

- convection currents in the asthenosphere drag the plates or
- gravity pulls down on subducting plates

Origin of magma: as you go deeper in the earth it gets hotter (geothermal gradient) at a rate of about 30 degrees per km. It is hot enough to melt rock in the upper mantle (50 to 250 km). Different minerals melt at different temps. Also need more heat to melt rock underpressure.

Isostatic adjustment: the crust adjusts up or down if the load on it is removed or added (i.e. glacier melts, volcano forms)

Volcanic Features

- Hotspots form when a stationary plume of magma breaks through the middle of the plate (intraplate). The plate moves and eventually the magma comes through a new spot. Sheild volcanoes are formed (basaltic, smooth flowing, low and wide volcanoes).
- Columnar jointing happens as basaltic magma (hot) cools slowly (long way to cool) and contracts forming polygonal shapes.
- Volcanic domes form when viscous lava oozes out (like toothpaste) and piles up near the vent.
- Lava plateaus - basalt floods an area (flood basalts)
- Nuee ardente (ash flow) - hot, fast, heavier than air flow that burns its way down the mountain. Usually out of an andesitic volcano.
- Pillow lava - when lava extrudes under water it form bulbous pillow shapes. The outside is often glassy with larger crystals inside.
- Aa lava - basaltic, slightly cooled so it is thicker, sharp, blocky shapes. Hurts to walk on.
- Pahoehoe lava - basaltic, skin forms on top, lava moving under causes wrinkles, ropy
- Plutonic features - batholith (large pluton of magma cooled), stock (smaller pluton), sill (parallel to layers), dike (cuts across layers), xenolith (fragment broken off in magma but not melted)

The rock cycle relates to plate tectonics: wherever magma cools (diverging plates, volcanoes) igneous rocks form, wherever plates collide metamorphic rocks form, and there is erosion everywhere and when those sediments lithify sedimentary rocks form.

Earthquakes

- creep - plates slowly move past each other, no build up of pressure
- elastic rebound - plates slowly move but are stuck along the edges, pressure builds until it finally snaps and the plates spring back to their original shape in the new location.
- magnitude - a measure of the ground motion (up by factors of 10) and energy released (up by factors of 30), Richter scale, no maximum
- intensity - a measure of the damage done, Mercalli scale, 12 is total destruction
- epicenter location - measure the difference in arrival times of the P (faster) and S (slower) waves, use the distance time graph to determine how far away the quake happened, draw a circle with the distance as the radius, three different stations do this and where the circles intersect is the epicenter
- seismic risks: geographic location (if you live near plate boundaries), topography (near mountains that will slide in an earthquake), ground strength (bedrock is best to build on, river sediments are worst), proximity to faults (the futher the better), construction design (hard to do using scale models, specifications always changing)
- earthquake prediction: dilatancy data (the amount of water in the rocks pore spaces, lubricates, see changes in the water level), seismic gap (area along known fault that hasnt had a quake in a long time - is due!), animal behaviour, land rising (pressure)

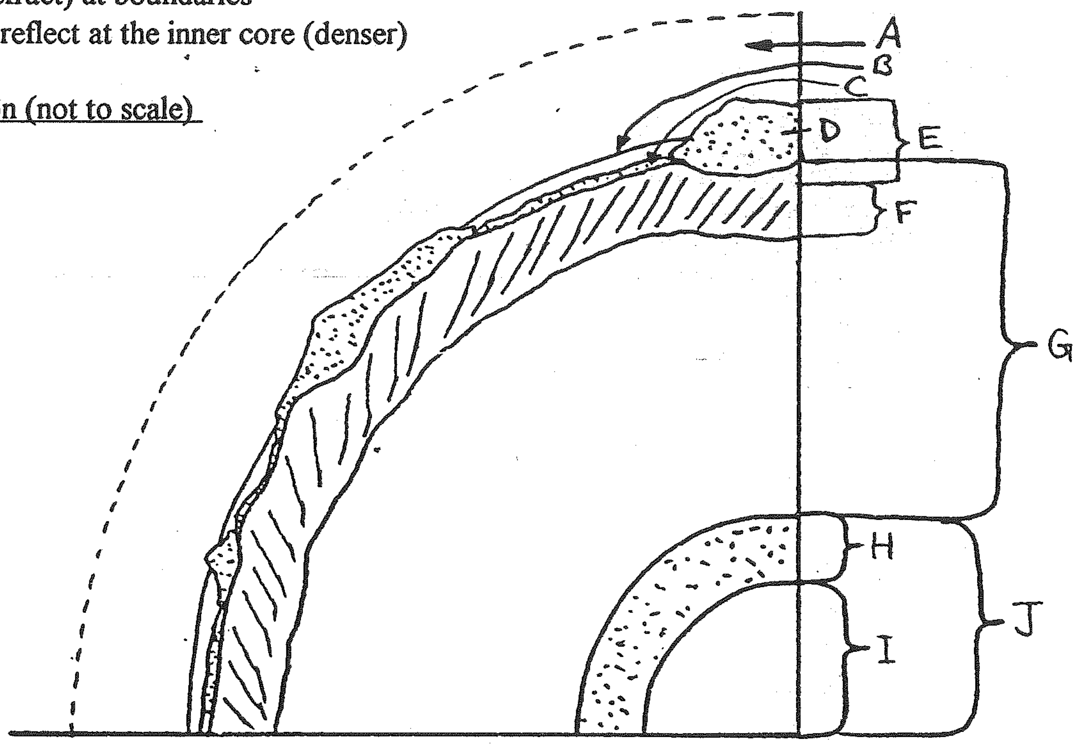
Name:___________________

Brief Internal Processes and Structures Summary Continued

Evidence that the earth is layered

- waves speed up at the Moho (btwn crust and mantle)
- S waves disappear at the outer core (liquid)
- waves bend (refract) at boundaries
- some P waves reflect at the inner core (denser)

Earths cross section (not to scale)



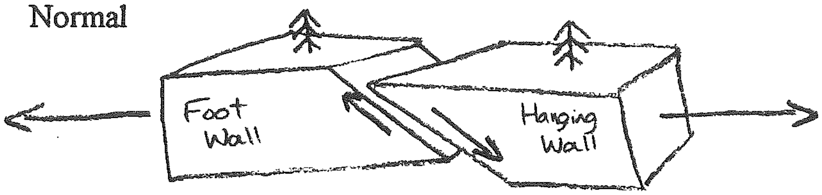
A - atmosphere, 80 km, 78% N, 21% O, 1% other
B - ocean, average depth 4 km, deepest 11 km (Marianas Trench), water
C - oceanic crust, 10 km, basalt
D - continental crust, 50 km, granitic
E - lithosphere, 50-100 km thick, solid
F - asthenosphere, to 500 km depth, plasticy
G - mantle, base of crust to 2900 km, silica and ferromagnesians
H - outer core, 2900 to 5000 km, liquid
I - inner core, 5000 to 6370 km, solid
J - core, 2900 to 6370 km, iron and nickle
Moho between D and G

Whether a rock will behave plasticly (change in shape permanent) or brittly (break) depends on temperature (higher = more plastic), confining pressure (more = more plastic) and the intrinsic characteristics of the rock

Faults are breaks in the rock where there has been movement whereas joints are fractures where there has not been movement.

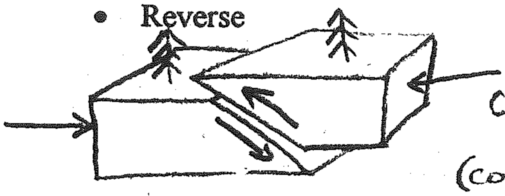
Dip-slip faults (vertical motion)

- Normal



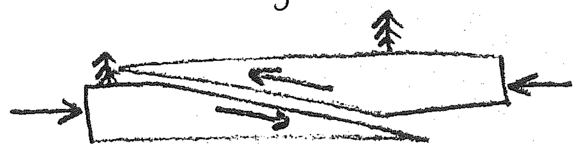
tensional forces (diverging plates)

- Reverse



compressional forces (converging plates)

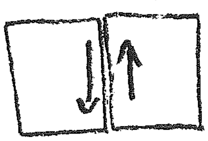
Thrust (lower angle)



Strike-slip faults (horizontal motion)

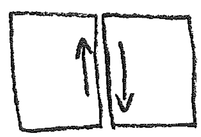
- left lateral

map (top) view



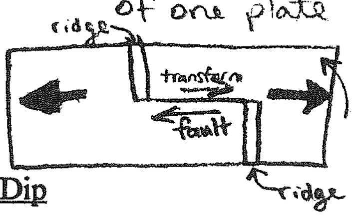
shear forces

right lateral



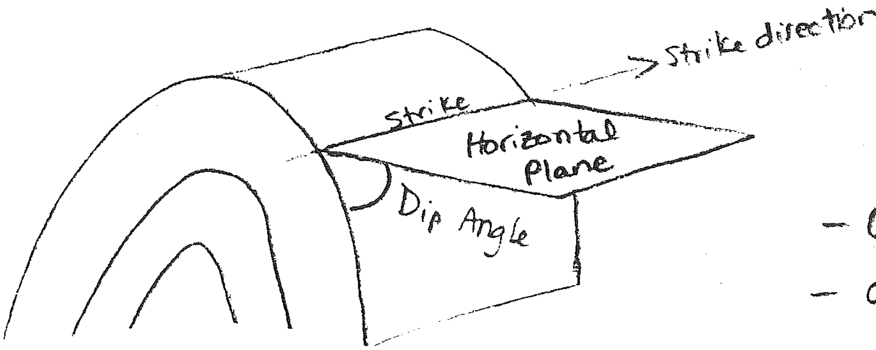
map view

- transform – happen at spreading ridge where there is some rotation of one plate



Strike and Dip

- Strike - the compass orientation of the line of intersection of a horizontal plane with the structure.
- Dip - the angle between the horizontal plane and the slope of the structure



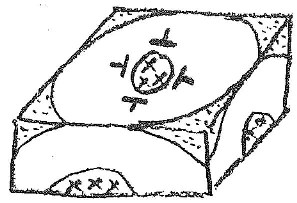
– only draw on map
– always looks like a capital T

Structure | **Block Diagram**

Strike is always parallel to the lines on the map.

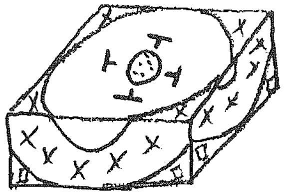
- dome (oldest in middle)

  looks like an upside down bowl

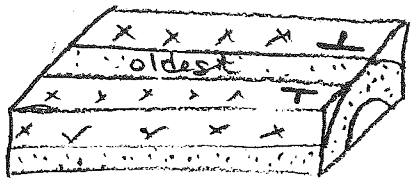


- basin (youngest in middle)

  looks like a bowl

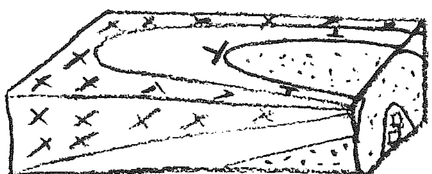


- anticline (ant hill)



oldest in middle on map view

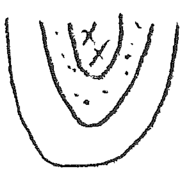
- plunging anticline

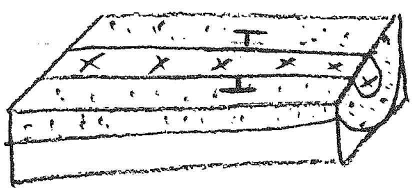


← plunge

anticlines plunge toward the nose

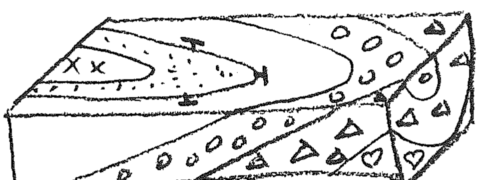
- syncline (smile)





youngest in middle

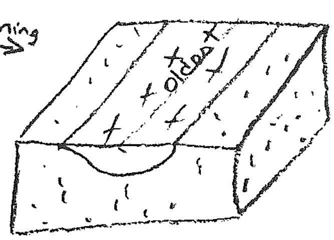
- plunging syncline



← plunge

synclines plunge toward the open end

- overturned fold



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